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MODELING OF THREE-DIMENSIONAL MAGNETOSTATIC ANALYSIS IN THE ANSYS WORKBENCH

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Magnetic fields may exist as a result of a current or a permanent magnet. Typical uses for a magnetostatic analysis are as follows:

- Electric machines
- Transformers
- Induction heating
- Solenoid actuators
- High-field magnets
- Nondestructive testing
- Magnetic stirring
- Electrolyzing cells
- Particle accelerators
- Medical and geophysical instruments.

This analysis is applicable only to 3-D geometry. The geometry must be a single solid body, a single solid multi body part, or a winding conductor body. Conductor bodies may be defined from solid CAD geometry, or, in special cases, from a CAD line-body. A magnetic field simulation requires that air surrounding the physical geometry be modeled as part of the overall geometry. Resulting model must be a single multi body part which includes the physical geometry and the air. Line bodies used to model windings may exist outside the multi body part.

In many cases, only a symmetric portion of a magnetic device is required for simulation. The geometry can either be modeled in full symmetry in the CAD system, or in partial symmetry.

Magnetic field simulation support 4 categories of material properties:

1. Linear “soft” magnetic materials - typically used in low saturation cases. A Relative Permeability is required. This may be constant, or orthotropic with respect to the coordinate system of the body (See Details View). Orthotropic properties are often used to simulate laminate materials.

2. Linear “hard” magnetic materials - used to model permanent magnets. The demagnetization curve of the magnet is assumed to be linear. Residual Induction and Coercive Force are required.

3. Nonlinear “soft” magnetic material - used to model devices which undergo magnetic saturation. A B-H curve is required. For orthotropic materials, you can assign the B-H curve in any of the orthotropic directions, while specifying a constant Relative Permeability in the other directions.

4. Nonlinear “hard” magnetic material - used to model nonlinear permanent magnets. A B-H curve modeling the material demagnetization curve is required.

Connections are not supported in a magnetostatic analysis. Solution accuracy is dependent on mesh density. Accurate force or torque calculations require a fine mesh in the air regions surrounding the bodies of interest. The use of pyramid elements in critical regions should be minimized. Pyramid elements are used to transition from hexagonal to tetrahedral elements. You can eliminate pyramid elements from the model by specifying Tetrahedrons using a Method mesh control tool.

By default the program will use the direct solver. Convergence is guaranteed with the direct solver. Use the Iterative solver only in cases where machine memory is an issue. The solution is not guaranteed to converge for the iterative solver.

You can apply electromagnetic excitations and boundary conditions to faces in Simulation. A boundary condition is considered to be a constraint on the field domain. An excitation is considered to be a non-zero boundary condition which causes an electric or magnetic excitation to the system. Boundary conditions are applied to the field domain at exterior faces. Excitations are applied to conductors.

Boundary conditions may also be applied on symmetry planes via a Symmetry folder. A Symmetry folder allows support for symmetry, anti-symmetry, and periodic conditions.

The Solution Information object provides some tools to monitor solution progress in the case of a nonlinear magnetostatic analysis. Solution Output continuously updates any listing output from the solver and provides valuable information on the behavior of the structure during the analysis. Any convergence data output in this printout can be graphically displayed as explained in the Solution Information section. Adaptive mesh refinement is available for magnetostatic analyses.

A magnetostatic analysis offers several results items for viewing.

- Electric Potential
- Flux Density
- Directional Flux Density
- Field Intensity
- Directional Field Intensity
- Force
- Directional Force/Torque
- Current Density
- Inductance
- Flux Linkage
- Error (Magnetic)

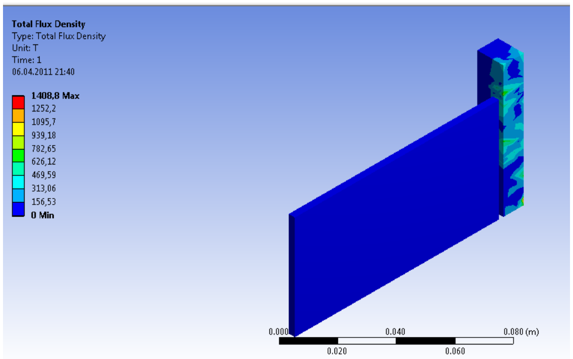

Figure 1 – Graphical result of Total Flux Density

Results may be scoped to bodies and, by default, all bodies will compute results for display. For Inductance or Flux Linkage, define these objects prior to solution. If you define these after a solution, you will need to re-solve.